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GEOLOGIC SETTING OF THE FOSSIL GOOSE BONES FOUND ON MOLOKAI ISLAND, HAWAII

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FIGURE 1.—Joan Aidem, discoverer of the fossil goose bones, standing next to lithified dune in which the bones were found. The large cave was made during excavation of the bones. Near Kalani Point, West Molokai, Hawaii.

In 1971 Mrs. Joan Aidem, of Kaunakakai, Molokai, found a skull and other bones of an extinct species of goose in lithified dunes (eolianites) along the windward coast of West Molokai (Figs. 1, 2). This area was named the Desert Strip by Wentworth (1925) because dunes stretch from the windward beach, ½ mile in width, for a distance of 5 miles inland. Two distinct types of dunes occur, those lithified and those composed of loose calcareous sand. The two types were mapped by Stearns and Macdonald (1947) and the sand-covered area renamed the Dune Strip.

Mrs. Aidem took the bones to the B. P. Bishop Museum, where Dr. Alan C. Ziegler (1972) recognized their importance. He went to Molokai where he collected an articulated skeleton belonging

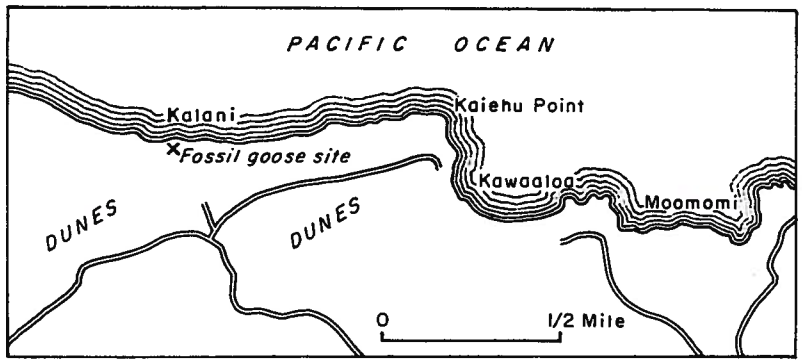

FIGURE 2.—Map of north coast of Molokai showing localities described in text.

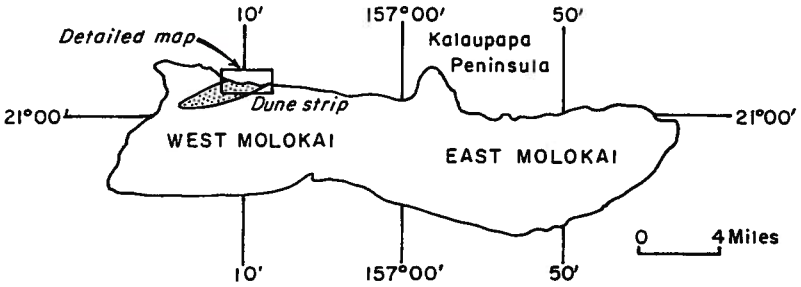

FIGURE 3.—Map of Molokai showing location of Dune Strip and detailed map shown in Figure 2.

to the original goose skull, which he shipped to Dr. Alexander Wetmore of the Smithsonian Institution. It is a flightless goose of Pleistocene age and not related to the living native goose of Hawaii, the *Nene (Branta sandvicensis)*. Fragments of another extinct goose skeleton were found under 80 feet of basaltic lava near Pahala, Hawaii island, by W. O. Clark (Stearns and Clark, 1930, p. 60) but it is not the same species as the one found on Molokai. The Hawaii island bird has been described by Wetmore (1943). The writer was shown the Molokai fossil site by Mrs. Aidem and Dr. Ziegler. We are indebted to Aka Hodgins, Manager of Molokai Ranch, Ltd., for permission to drive to the site. All photographs are by the author.

GEOLOGY

The goose bones have been found in several places in the Moomomi Beach area, but the locality from which the skeleton was removed and sent to the Smithsonian Institution was a lithified dune about 130 feet from the ocean edge at Kalani Point and about 10 feet above sea level. The dune is weakly cemented at the point where the bones were found but more firmly cemented higher up. The dune is the erosional remnant of a much more extensive dune (Fig. 3). Fossil land snails collected by Mrs. Aidem adjacent to the bones have a C^{14} age of 25,150± 1,000 years B.P., as determined by Dr. Robert W. Buddemeier of the Hawaii Institute of Geophysics (Sample HIG-35; letter dated Nov. 17, 1972). The dune consists of coarse windblown calcareous sand derived from shells, corals, and foraminifers.

LOWER LITHIFIED DUNE

A geologic section of the rocks between the beach and the dune is shown in Figure 4. The oldest rocks are hard eolianite extending an unknown distance below sea level. An extensive platform has been eroded into the ancient dune about 1 foot below mean sea level by the present sea, and in places the sea has notched the dune (Fig. 5). Such features are chiefly the work of solution. The dune above sea level is very rough and contains solution pits as much as 2 feet deep and 2 feet in diameter. The rock is hard enough to be crushed for aggregate, a character of dunes on other Hawaiian islands which are mid-Pleistocene in age (Stearns, 1970).

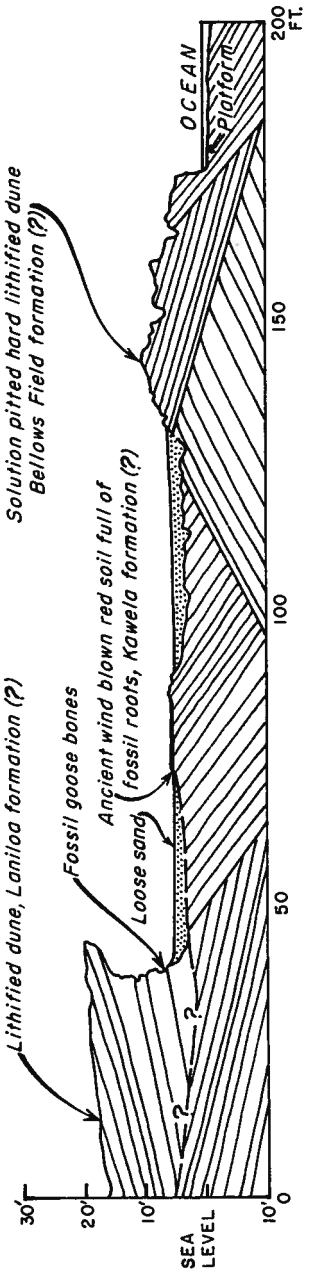

FIGURE 4.—Geologic section at the fossil goose locality at Kalani Point near Moomomi Beach, island of Molokai, Hawaii. Bedding planes generalized.

FIGURE 5.—Solution pitted Illinoian (?) dune limestone forming Kalani Point, West Molokai, Hawaii. Note platform awash, made by present sea.

FIGURE 6.—Ancient soil bed of Kawela age (?) about 5 feet above mean sea level, containing fossil land snails and roots. Bed underlies fossil goose bones at Kalani Point, West Molokai, Hawaii. Overlies dune shown in Figure 5.

Because the dune extends below sea level, it must have reached this place when the sea was below its present level. This eolianite is tentatively correlated with the Bellows Field formation of Illinoian age (Lum and Stearns, 1970, p. 11), blown inland when the sea was about 350 feet below present level, about 320,000 years B.P. The dune was later truncated by erosion 5 to 10 feet above sea level, presumably by the 25-foot stand of the sea, although no deposits of that sea were found in the area. However, chunks of hard caliche lie scattered over the bench which in places is as much as 50 feet wide. The bench parallels the ocean and it is difficult to imagine wind cutting such a flat bench. Numerous fossil tree trunks, mostly less than 4 inches in diameter, stand in relief on the bench.

Farther west the older dunes sit in the ocean at the foot of high basaltic cliffs where the sand had to come from reefs then high and dry and now deeply drowned.

SOIL BED

A lithified reddish fine-grained soil bed 6 inches to 1 foot thick lies unconformably upon the lower eolianite (Fig. 6). It is crisscrossed with calcareous root casts indicating it was once covered with dense vegetation. It contains abundant fossil land snails and ¼ mile westward along the beach it thickens to 3 feet and contains thousands of fossil snail shells (Fig. 7). Shells collected by Mrs. Aidem from this latter locality have a C^{14} age of more than 27,000 years B.P., as determined by Geochron Laboratories, Inc. (Sample GX-2672). Dr. Richard Ku of the University of Southern California reports an ionium age of 28,000± 3,000 years (Letter to the writer dated Jan. 30, 1973), for part of the same sample of shells sent to Geochron Laboratories.[1] This date confirms Buddemeier's C^{14} date for similar fossil snails from an outcrop 2 feet stratigraphically higher. The soil is windblown dust derived from a weathered basaltic terrane but, at the locality shown in Figure 7, it contains abundant calcareous grains and the shells appear to have been transported to the site by wind or by water, or both. The soil can be traced in one place below sea level and, in another place, at least 100 feet above sea level. Possibly it signifies a great change in climatological and environmental conditions from the present. The winds at present are northeast trades and they have been dominant for most of Quaternary time, as indicated by the Dune Strip extending to the southwest for 5 miles (Fig. 3). The red dust had to be blown

from a southerly direction indicating that antitrades prevailed dur ing its deposition, unless extensive soil-covered basalt lies not fa below sea level which was exposed to trade winds during the las glacial epoch when the sea was lower. It is correlated tentativel with the soil of the Kawela low stand on Oahu of Wisconsinai age (Stearns, 1970). On the west side of Kawaaloa Bay (Fig. 2 the soil bed splits into two layers and has a lithified dune 25 fee thick between them. The interbedded dune indicated that som "coral" sand was blown inland by trade winds during this epoch

UPPER LITHIFIED DUNE

An eroded lithified dune 15 feet thick lies above the soil be (Figs. 1, 4). The calcareous sand is weakly cemented for 5 feet abov the soil bed. This condition greatly facilitated the removal of th goose bones which were found near the base of the dune. Foss land snails occur sparingly in the bone layer. The upper part o the dune is fairly well cemented (Fig. 1), but is much weaker tha the hard eolianite below the soil layer. The upper dune also ble inland when the sea was lower. Dunes of this epoch extend fo miles inland and are distinguished readily by their hard gray lime stone carapace. Some have rough surfaces and caves caused b subsequent wind erosion. Most of the loose sand in the Dune Stri has been eroded from the older dunes. Numerous deep blowout occur. They generally bottom on the lithified soil layer which i wind resistant. The upper lithified dune is tentatively correlate with the Laniloa formation of Wisconsinan age on Oahu (Stearn 1970).

Bones of several other extinct and still living species of bird have been found by Mrs. Aidem on or above the ancient soil horizo eroded out of the overlying dunes. Basalt flakes, round beach cob bles, and numerous *opihi,* cowrie and other shells left by ancie Hawaiians are found in the blowouts. Other small fragments c basalt not obviously left by the Hawaiians abound in the blowout Their origin is at present unknown.

LOOSE SAND

The numerous recent sand dunes are composed of loose san blown from beaches. However, it is obvious from their extensi distribution that they are derived mostly from the older underlyin and adjacent lithified dunes, chiefly of upper dune age.

TSUNAMI BOULDERS

In a swale at the end of the road leading to Kaiehu Point, shown in Figure 2, numerous scattered round boulders and logs lie about 40 feet above sea level 50 to 100 feet inland of the beach. They were left by tsunami waves, probably by the waves of 1946 and 1960.

FIGURE 7.—Ancient soil layer full of fossil land snails of Kawela age (?) about 6 feet above mean sea level, ¼ mile west of Kalani Point, West Molokai, Hawaii.

CONCLUSION

The fossil goose skeleton was found in a lithified calcareous dune with a carbon 14 age of about 25,000 years B.P., deposited when the sea was lower than at present during the late Wisconsinan or last glacial epoch. How long the species inhabited Molokai before it became flightless is unknown.

NOTES

*Volume XXIV of the Occasional Papers is published in honor of Edwin Bryan, Jr., whose service to Bishop Museum began in 1919. He was for ma years Curator of Collections, and at present is Manager of the Museum's Paci Scientific Information Center. A Symposium, at which several of the papers this volume were read, was held at the Museum on April 13, 1968, honoring M Bryan on the occasion of his 70th birthday.

†The work done by T. L. Ku on the uranium-series dating was supported the Earth Science Section, National Science Foundation, NSF Grant GA-3618

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